Business Cycle Affiliations in the Context of European Integration

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1 Introduction

There is an obvious and intense interest within Europe as to the nature of the links between growth in the countries of the Economic and Monetary Union (EMU). Such growth is often referred to in terms of so-called business cycle movements, and a key issue is the extent to which monetary integration may imply a single, common, business cycle across the countries of the EMU, so that their short-run and medium-run growth experiences will be inextricably linked. If there is to be (ultimately) such a common business cycle, it should be anticipated that the affiliations across European countries will have become progressively stronger over time. Indeed, the commencement of the European Monetary System (EMS) in 1979 marks a particularly important date in this context, and papers have frequently examined relationships for growth across European countries separately for the pre- and post-EMS periods; see, for example, Artis and Zhang (1997, 1999). In these papers, Artis and Zhang find increased integration since 1979 for the member countries of the European Exchange Rate Mechanism, with increased contemporaneous correlation with Germany and lower correlation with the US. In contrast, by sub-dividing both the pre- and post-EMS periods, Inklaar and de Haan (2001) have argued that finer sub-periods show different patterns, and that there is no systematic relationship between business cycle affiliations and monetary integration.

In a wider international context, it has become a "stylised fact" that whereas business cycle affiliations among the countries of the EMU have generally increased, European economies (with the notable exception of the UK) generally became "disjoint" from the US in the 1990s. Therefore, the almost simultaneous occurrence

of recession in the US and major European economies during 2000 was a surprise to policy-makers; see, for example, discussions in IMF (2001), OECD (2002), and, in connection with the US Federal Reserve Board, Doyle and Faust (2002). If, indeed, European and US business cycles were essentially unrelated during the 1990s, the challenge has been to find the explanation for the dramatic change in this pattern at the turn of the century. An alternative, and (to our knowledge) unexplored, possibility is that the "stylised fact" of disjoint business cycles is a fallacy.

This paper examines evidence on the changing relationships over time in business cycle movements, with various measures (based on the output gap and growth rates) used to capture these movements. Our focus is on Europe, including countries both inside and outside EMU, but we set this in an international context by including the non-European G7 countries of the US, Canada and Japan. The technique we use is the conventional one of correlation analysis for each country with Germany and with the US, but this correlation analysis is employed on both a rolling basis and also for specific sub-periods related to important economic events in Europe.

This analysis of changing affiliations is based on correlations in order to avoid imposing restrictions on the data that may not be valid. In particular, the type of series we examine are known to be subject to volatility changes and other structural breaks since the 1970s; van Dijk, Osborn and Sensier (2002) analyse these for the G7 countries and find that some of the important breaks are important for all countries. It is anticipated that rolling correlations and correlations over sub-periods should be relatively robust to such breaks.

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We follow others, including Artis and Zhang (1997, 1999), Inklaar and de Haan (2001), and IMF (2001), by examining business cycle affiliations using real output after removal of the trend by application of the Hodrick-Prescott (HP) filter; see Hodrick and Prescott (1997). Instead of monthly industrial production used in some studies, we prefer quarterly real gross domestic product (GDP), since GDP better reflects the general economy. However, in addition to HP-detrended data, we also examine the robustness of our results by using the Baxter and King (1999) filter and the annual growth rates. To allow us to comment on lead/lag relationships over time, we follow Artis and Zhang (1997) in examining maximum correlations, as well as contemporaneous correlations.

Our general finding of increased integration over time for the countries of the EMU with Germany accords with that of others. However, we also find that the beginning of the 1990s is distinctive in terms of the relationship of these countries with the US, possibly due to effects associated with German reunification. Indeed, in contrast to the view that the business cycle in EMU countries became disjoint from that in the US around 1990, we find that the US has led movements in Europe since 1993. In this context, therefore, the apparent transmission of the US recession of 2000 to European countries is not a surprise.

The structure of the paper is as follows. The countries and variables we examine are discussed in Section 2, including the rationale for the sub-periods analysed. We then examine results for affiliations in the business cycle as measured by HP filtered GDP in Section 3, with Section 4 then examining robustness of the findings to other

measures of the business cycle. Conclusions and some further discussion complete the paper in Section 5.

2. Data: Countries, Variables and Sample Periods

We analyse eight countries of the EMU, namely: Austria (denoted AUT), Belgium (BEL), Finland (FIN), France (FRA), Germany (DEU), Italy (ITA), Netherlands (NDL) and Spain (ESP). Limitations on data availability meant that we do not include all EMU countries, with Greece, Ireland, Luxembourg and Portugal excluded. Other European countries analysed are Sweden (SWE) and the UK (UK), both non-EMU countries of the European Union. For comparison, we include the non-European G7 countries, namely the US (USA), Canada (CAN) and Japan (JPN). In most cases, we employ real GDP data over the period 1960Q1 to 2002Q1, although the data series for a few countries begin later[1]. Full details of all data, including sample periods and sources, are given in Appendix 1.

As already mentioned, our analysis is based on correlations. The three data transformations used can be considered as being of two different types. The first type is filtering using methods such as those of HP and Baxter-King (BK), whereas the second uses growth rates computed as annual differences of log GDP. It is important to appreciate that these two types of measures represent different concepts of the business cycle. Both the HP and BK filters remove a trend, and hence the filtered series relate to the growth cycle, which considers movements above or below an

1. Our criterion for inclusion is that quarterly data are available in the *Main Economic Indicators* database of the OECD from 1980Q1 or earlier.

underlying trend. Indeed, since the BK filter is focused on movements with periodicity from six to 32 quarters (see Baxter and King, 1999), it also removes very short-run fluctuations, in addition to those associated with the long-run. Detrended output series are frequently taken as measures of the output gap, as in IMF (2001). Due to the averaging properties of these filters, the resulting series tends to be relatively smooth. Although the quarterly growth rate in real GDP can be quite erratic, some of this erratic short-run movement is eliminated by our use of annual differences, since annual differencing is equivalent to the annual moving sum of the first differences[2]. In terms of the business cycle, these growth rate measures relate to the so-called classical business cycle, which examines the underlying direction of change of the economy (so that growth is typically positive in expansion and negative in recession). Since there is no simple one-to-one relationship between output gap and growth rate measures, these will not necessarily reveal the same patterns.

The primary results presented here are obtained using the HP filter[3], with Section 4 showing results for the BK filtered series and the annual growth rate, so that the two types of data transformations are considered. However, qualitatively similar results are obtained for all three filters considered[4].

We follow Artis and Zhang (1997, 1999) and Inklaar and de Haan (2001) in using the commencement of the EMS 1979 as a defining period in European integration, and hence our sub-period analysis uses this date as one point of separation. We then

2. This follows from the simple (and well known) identity $1 - L^4 = (1 - L) + (L - L^2) + (L^2 - L^3) + (L^3 - L^4)$, where L is the conventional lag operator and the data are quarterly.
3. We use $\lambda = 1{,}600$ in the HP filter, which is the conventional value for quarterly data. This is applied after transformation by taking the logarithm.
4. Results obtained using quarterly differences are obtainable from the authors on request.

follow Inklaar and de Haan (2001) in examining further sub-divisions. However, their temporal sub-divisions appear to be arbitrary. In order to focus on evolving relations post-EMS, we divide the post-1980 period into 1980Q1-1990Q4 and 1991Q1-2002Q1. Two important events point to a date around the end of 1990 as an appropriate date for splitting the sample. These are the decision taken at an Intergovernmental Conference in December 1990 to introduce a single currency for the European Union and the reunification of Germany in October 1990. However, we also recognise that the period 1991-1992 contains a number of notable events in the European context, which may be reflected in fluctuating cross-country relationships. In particular, the effects of German reunification, the ERM crisis of 1992 and uncertainty around the establishment of EMU in the period around the signing of the Maastricht Treaty in February 1992 may have temporarily altered affiliations in a nontrivial way. To avoid potential temporary instabilities early in the 1990s and to allow for the establishment of the EMU, we also examine separately the sub-period 1993-2002.

3. Business Cycle Affiliations

Figure 1 shows the rolling contemporary correlations for HP detrended GDP of Germany with selected other countries in our sample. The countries included in the upper panel are the major EMU economies of France, Italy and Spain, together with the Netherlands as a small (but "core") European country. The lower panel of the figure shows correlations of Germany with the G7 countries that are non members of the Euro Area, namely USA, Canada, the UK and Japan. These, and all rolling correlations, are computed using a window of 40 observations (10 years), with the

value shown being centred at the mid-point of this window. For convenience, our discussion refers to this mid-point as the date to which the correlation relates.

The correlation with France in Figure 1 shows a time-varying pattern: it increases almost monotonically between 1965 to 1975, then declines to nearly zero around 1985, before starting a new upward trend. Although the correlations with Spain and Italy exhibit different trajectories until the late 1980s, their patterns from this period are similar to each other and to that with France. This might be anticipated in the case of Spain, since it did not join the European Union until 1986 and the ERM until 1989. Relative to these patterns, the correlation with Netherlands shows little variation, but a general upward trend is evident. Overall, the correlations are highest during the 1970s, probably due to the effects of the first oil shock. After the second oil shock (1979), countries adopted different stabilisation policy and this may have caused the correlation to decrease. But from 1985 (corresponding to the period 1980-90, because the windows is of 10 years), that is from the commencement of the ERM, the correlation monotonically increases for the European economies. Thus, the late 1980s onwards appears to be an important period in the development of economic integration for these countries, with their correlations with Germany lying between approximately 0.6 to 0.8 from 1995, compared with much wider bands (and generally lower levels) prior to 1985.

The patterns of the rolling correlations in the lower panel of Figure 1 stand in contrast to those of the upper panel. With the exception of Japan from around 1987, they all follow the same general pattern, being highest at around 0.7 between the mid-1970s and mid-1980s. From 1987 until 1995, the USA, Canada and the UK

appear disjoint with Germany, with negative contemporaneous correlations indicating that their business cycle movements are out of phase. Thus, Figure 1 captures the "stylised facts" of business cycle relationships within Europe and internationally. Indeed, the pattern of association of Germany with the US in Figure 1 is strikingly similar to that shown in IMF (2001), underlying the apparent dissociation of the European and US business cycles during the 1990s. These twin facts (increasing correlation among ERM countries and lower correlation with the US) have led some authors to talk about the emergence of a European business cycle from the commencement of the ERM in 1979.

Following Artis and Zhang (1997), we also analyse lead/lag relationships, showing in Figure 2 for each country the maximum positive correlation with Germany, computed over all leads and lags to a maximum of five quarters[5]. Once again, the upper panel clearly points to increasing integration in relation to Germany for the EMU countries, at least from the mid-1980s onwards. The lower panel, however, gives a different view from Figure 1 of German business cycle affiliations with the US, Canada and the UK, since the correlations in Figure 2 remain positive (and generally around 0.4) throughout the 1980s and 1990s.

Further light on these business cycle affiliations is shed in Figures 3 and 4, which show the corresponding contemporaneous and maximum correlation values, but now expressed in relation to the US. Like Figure 1, the contemporary correlations in Figure 3 indicate a separation of the business cycle of the EMU countries and the US around 1990, although this is more marked for Germany than other countries. This

5. That is, for each (centred) time period t, we compute the correlation of GDP in a country with German GDP for periods $t - 5$, …, t, …, $t + 5$. Among these 11 correlations, the one with the maximum positive value is shown.

separation does not occur for the UK, indicating the emergence of what some authors have called an Anglo-Saxon cycle, possibly reflecting the fact that the cycles of the US and UK react to world influences, while countries that have tied-up their exchanges rates through the ERM are more closely related to each other. However, the separation of continental European economies from the US is less evident in the maximum correlations of Figure 4. Indeed, for much of the 1990s these are around 0.4 - 0.7, with only Germany being lower than this range for a substantial period. At least for France and Spain, the period of business cycle movements being disjoint from the US is the 1980s, rather than the 1990s. For Germany, declining correlations with the US are arrested in the late 1980s, and subsequently these tend to increase except for approximately two years around the mid-1990s. Overall, the results in the upper panel of Figure 4 do not suggest disjoint cycles in the 1990s for these countries with those of the US. The different implications here compared with those of the corresponding contemporaneous correlations in Figure 3 suggest that at least part of the story of the apparently changing business cycle affiliations concerns lead/lag relationships.

We investigate these issues further in Tables 1A and 1B, which show the correlations of HP detrended GDP for (respectively) Germany and the US with each other country of our sample. We include correlations computed over the whole data period and for each of our sub-periods (1960-1979, 1980-1990, 1991-2002 and 1993-2002). The contemporaneous and maximum (over leads and lags of five quarters) correlations are shown, together with the corresponding lead time for Germany or the US (as appropriate). Thus, a lead of, say, -2 for the maximum correlation with

Germany implies that the maximum positive correlation occurs with that country leading Germany by two quarters.

The patterns for the EMU countries in Table 1A reinforce the comments made above in relation to France, Italy and Spain from Figure 1. It is notable that for these countries, together with the other EMU countries of Belgium, Austria and the Netherlands, the contemporaneous correlations over the shorter period 1993-2002 are largely unchanged from those over 1991-2002. Further, considering the maximum, rather than contemporaneous, correlations makes little difference for these countries.

In contrast, the contemporaneous correlations for the UK, US and Canada with Germany are apparently dominated by large negative relationships over 1991-1992, since when these two years are excluded the evidence disappears that their business cycles are disjoint from that of Germany. Indeed, in terms of the sub-periods analysed, the contemporaneous correlations of Germany with these countries is at their highest during 1993-2002, with that between the UK and Germany being at a level similar to that of all EMU countries. The impact of these two years is also marked in terms of the maximum positive correlations, with each of the US, Canada and the UK apparently leading Germany by five quarters over 1991-2002, with this lead being reduced to only one or two quarters over the sub-period from 1993.

The values shown in relation to the US in Table 1B emphasise two things. Firstly, the exclusion of 1991-1992 has a large impact on the correlations of the US with all EMU countries except Finland, again indicating that this period is atypical. Secondly, the US plays an important role in relation to the growth cycle for all

European countries, especially since 1993. Indeed, the results for this latter period imply that the US output gap leads each European country (both EMU and non-EMU) by one or two quarters, with a maximum correlation of similar magnitude to that for the country with Germany over the same period. The only country substantially disjoint from the US after 1993 is Japan.

At least from this analysis of HP filtered data, the conclusion of IMF (2001), Doyle and Faust (2002) and others that the business cycle movements in continental European countries were disjoint from the US during the 1990s is mistaken. The period 1991-1992 is evidently distinctive for these European countries in their relationships with the US, possibly due to the economic effects on the European economies of the increase in interest rates by the Bundesbank after German reunification. However, when these two years are omitted, the role of the US in leading these European economies is clear. It is also clear from rolling correlations that take account of lead/lag relationships.

Summarising, the rolling and sub-sample analyses highlight four facts, namely (i) increasing comovement among the cycles of the ERM countries from the start of the ERM (ii) apparently the Anglo-Saxon economies not inside the ERM were largely out of phase with the other economies and there is also an increase in the correlation among the three Anglo-Saxon economies (US, CAN and UK) (iii) the decrease in the correlation between ERM countries and Anglo-Saxon countries was more marked with Germany and apparently it is related to the experience of 1991-1992 (iv) if we omit 1991-1992, the path of the synchronicity seems to be upward for all the economies.

Therefore, alongside the increased business cycle synchronicity among the ERM economies, it seems that the principal factor that moves the international business cycle is a global tendency towards higher comovement (globalisation, see Andersen and Herbertsson (2005) for a quantification of this phenomena), that is altered by some specific events (such as German reunification). Another possibility is that business cycle dynamics are asymmetric phenomena (see Andreano and Savio (2002) for recent evidence of asymmetries in the G7 business cycles), with higher correlations for negative shocks. Thus, recessions may be more quickly transmitted, leading to higher correlations in the 1970s and around 2000 than in other periods.

The results point toward higher international linkages among the business cycles of individual countries (globalisation) but also indicate that the ERM, and now the EMU, had the effects of increasing the comovement among participating economies. This is shown by the fact that the correlation with the US was only changed in the 1991-1992 period for the ERM countries.

4. Robustness Analysis

To verify that the results discussed in Section 3 are not a spurious consequence of the use of the HP filter, correlations corresponding to those shown in Tables 1A and 1B are presented in panels A and B of Tables 2 and 3 for other filters applied to log GDP.

Although there are some differences in the detailed results[6], the general pattern of correlations in Tables 2A and 2B, when the BK filter is used, are very similar overall to those of Tables 1A and 1B. In particular, although the maximum correlation for the US with Germany is only a relatively modest 0.37 over 1993-2002 in Table 2A, Table 2B reinforces the important role for the US in leading the EMU countries during the 1990s. Further, the results of Table 2A agree with those of Table 1A that the UK, as well as the US and Canada, has led the business cycle in Germany since 1980.

The use of annual growth rates in Tables 3A and 3B tells a similar story in terms of the pattern of relationships with Germany and the US. That is, the major EMU countries of France, Italy, Spain and UK have generally increasingly strong relationships with Germany over time, and their largest contemporaneous and maximum correlations occur in the period since 1993 (see Table 3A). Further, there is little evidence of important EMU countries becoming disjoint from the US in the 1990s, especially in the period since 1993 (Table 3B). The pattern of the US leading growth in the economies of Europe during the 1990s is, once again, clear whether 1991-1992 is included or excluded. In contrast, the lead/lag relationships for Germany in relation to other EMU countries over the 1990s is not evident from Tables 1A, 2A and 3A, because the values of the contemporaneous and maximum correlation are almost always very similar.

6. In some instances the BK filter correlations suffer from "small sample" problems, due to the loss of 12 observations at both ends of the total sample when this filter is applied. This is, for example, the case with the correlations of 0.99 found for both Germany and the US with Finland over 1960-1979. Since we have observations for Finland only from 1975, the loss of three years data with the BK filter implies very few available data points in this sub-period. Also, results for the maximum correlations of Germany with the US in Tables 2A and 2B are not always the same, since the period is measured in relation to dates for Germany in Table 2A and for the US in Table 2B. In a small number of cases, no maximum correlation or lead/lag is given because all correlations for leads/lags of –5, …, 0, …, 5 are negative.

5. Discussion and Conclusions

We believe that this analysis of the business cycle affiliations for EMU and non-EMU countries has thrown new light on the nature of changes in international business cycles.

An important finding of this paper is that the belief that Europe became disjoint from the US in the early 1990s is incorrect, and is based on an undue reliance on contemporary correlations obtained from detrended output data. If lead/lag relationships are considered through maximum correlations based on growth cycle measures (using HP or BK detrended data), or if classical business cycles are examined through the use of growth rate data, then this discontinuity largely disappears. Nevertheless, we do find evidence that the years 1991 and 1992 represent a temporary break in the relationship of a number of important European countries (especially Germany) with the US. However, we also find that the business cycle relationship between European countries and the US since 1993 is particularly strong by post-war standards, with the US economy leading European countries by between one and five quarters. In the companion paper Artis, Osborn and Perez (2004), we pursue this analysis in the context of international VAR models, showing that the essential results obtained here carry over to that multi-country setting.

One theme of the analysis of the present paper is the relationship between Germany and the US, since Germany is often considered to be the economic leader within the EMU. Our conclusions are summarised by the top panel Figure 5, showing rolling correlations for the growth cycle (HP detrended log GDP), including the

contemporary correlation and the maximum positive correlation (over leads and lags of five quarters, as above). In addition, we show the lead time for the maximum correlation, with this lead time scaled by division by 10 and expressed in relation to Germany; for example, a lead of –0.1 implies a one quarter lag for Germany (that is, a lead for the US).

This graph shows that the US has consistently led the output gap of Germany by one quarter, with the values of the maximum and contemporary correlations being very close, until the late-1980s. For a time, the business cycles in the two countries are then out of phase in terms of contemporary correlations. However, the dynamics of the relationship also apparently change, with the US attaining a longer lead of five quarters, before reverting to the previous one quarter lead for the US. Nevertheless, throughout the whole sample period, the US economy leads that of Germany.

There is a large literature on the links between countries that may give rise to the international propagation of business cycles. Although one obvious propagation mechanism is trade, it is now established that trade links are not sufficiently strong, and do not act sufficiently quickly, to be able to provide the principal transmission mechanism (IMF, 2001). Therefore, interest has turned to the roles of financial links and monetary policy. Although monetary policy is often represented through exchange rate volatility (Artis and Zhang, 1999, Inklaar and de Haan, 2001), it might be considered more directly through interest rates. Therefore, the other panels of Figure 5 consider rolling correlations between annual changes in nominal short-term (central panel) and long-term (lower panel) interest rates. As above, the use of annual

changes smoothes very short-run fluctuations and, especially for short-term interest rates, annual changes may be taken as indicating the monetary policy stance.

Short-term interest rates for Germany and the US are highly (and generally increasingly) correlated until the clear break in the mid-1980s, with this break being virtually synchronous with the break in the output gap relationship. It is also notable that the US consistently leads German interest rates by one quarter until this period, when (as with the output gap), the lead increases to five quarters. Finally the long-term interest rate show a much clearer tendency to increase over time, possibly because the long-term interest rate better reflects the globalization of financial markets and is more closed to policy influences. A similar picture emerges among the three variables if we focus on the US and another ERM country (but not the UK). This result indicates the tendency to higher correlation over time, but that specific events, such as German unification and the subsequent tightening of the monetary policy by the Bundesbank, could have important effects in the short run.

Although simple descriptive information, such as that in Figure 5, is only suggestive, the approximate concurrence of the break in the business cycle relationship with those occurring for the interest rates series indicates a potentially important role for monetary and financial factors for business cycle affiliations. Monetary policy is, of course, crucial to the success of the EMU, with short-term interest rates of participating countries now being set by the European Central Bank. However, despite a substantial literature on linkages between interest rates (including Artis and Zhang, 1998, Katsimbris and Miller, 1993, Laopodis, 2002), there is relatively little

analysis of the role of interest rates for business cycle affiliations. We plan to pursue this in further research.

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Appendix 1

Data

All data are quarterly and come from the OECD and IMF databases. For all the countries except Italy and Germany, GDP is from the Main Economic Indicators database of the OECD. Concretely our measure of GDP is: GDP volume index sa (the code typically is country_NAGVVO01_IXOBSA)

In order to obtain sufficiently long samples, other sources are used for Germany and Italy. For Germany the series GDP (PAN BD from 1991) CONA (with Datastream code BDGDP…D) is used. This series is from the OECD National Accounts and we correct it to take account of the jump in 1991, due to German reunification. For Italy, GDP volume index from the IMF is used (13699BVRZF…); this is corrected in 1970 and 1966 for a jump and an outlier respectively.

The sample periods for our data are:

DEU	60:1- 02:2	**BEL**	80:1- 02:1	**USA**	60:1- 02:1
FRA	60:1- 02:1	**AUT**	64:1- 02:1	**CAN**	60:1- 02:1
ITA	60:1- 01:4	**FIN**	75:1- 02:1	**JPN**	60:1- 02:1
ESP	70:1 -02:1	**UK**	60:1- 02:2		
NLD	60:1- 02:1	**SWE**	80:1- 02:1		

Details of the German and US interest rate series are:

	Short rate	Long rate
DEU	IMF line 60B (13460B..ZF...)	IMF line 61 (13461...ZF...)
USA	IMF line 60B (11160B..ZF...)	IMF line 61 (11161...ZF...)

The sample period for all interest rates series is 1960:1 to 2002:3.

Table 1A: **Correlation of HP filtered GDP with respect to Germany**

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 - 2002
DEU	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
FRA	Contem. corr.	0.56	0.61	0.30	0.79	0.79
	Max. corr.	0.56	0.61	0.55	0.79	0.79
	Lead/lag	0	0	-4	0	0
ITA	Contem. corr.	0.27	0.16	0.56	0.67	0.63
	Max. corr.	0.27	0.16	0.56	0.67	0.65
	Lead/lag	0	0	0	0	1
ESP	Contem. corr.	0.36	0.23	0.21	0.78	0.64
	Max. corr.	0.36	0.35	0.46	0.81	0.66
	Lead/lag	0	2	-5	-1	-1
NLD	Contem. corr.	0.50	0.40	0.70	0.69	0.57
	Max. corr.	0.50	0.40	0.74	0.73	0.60
	Lead/lag	0	0	-1	-1	-1
BEL	Contem. corr.	0.66	-	0.56	0.81	0.83
	Max. corr.	0.66	-	0.56	0.81	0.83
	Lead/lag	0	-	0	0	0
AUT	Contem. corr.	0.62	0.60	0.58	0.73	0.61
	Max. corr.	0.62	0.66	0.58	0.73	0.61
	Lead/lag	0	2	0	0	0
FIN	Contem. corr.	0.10	-0.27	0.26	0.27	0.62
	Max. corr.	0.26	0.54	0.48	0.54	0.71
	Lead/lag	-4	5	-3	-5	-1
USA	Contem. corr.	0.33	0.36	0.47	-0.05	0.57
	Max. corr.	0.41	0.43	0.56	0.31	0.68
	Lead/lag	-1	-1	-2	-5	-2
CAN	Contem. corr.	0.26	0.33	0.40	-0.02	0.67
	Max. corr.	0.27	0.38	0.47	0.36	0.79
	Lead/lag	-1	1	-1	-5	-2
UK	Contem. corr.	0.36	0.54	0.11	-0.09	0.61
	Max. corr.	0.39	0.54	0.53	0.37	0.64
	Lead/lag	-1	0	-5	-5	-1
JPN	Contem. corr.	0.48	0.48	0.47	0.50	0.27
	Max. corr.	0.49	0.48	0.57	0.53	0.30
	Lead/lag	-1	0	-1	-1	-1
SWE	Contem. corr.	0.53	-	0.52	0.62	0.68
	Max. corr.	0.56	-	0.52	0.69	0.69
	Lead/lag	-1	-	0	-1	-1

For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead (lag) of Germany if the value is positive (negative).

Table 1B: Correlation of HP filtered GDP with respect to US

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 - 2002
DEU	Contem. corr.	0.33	0.36	0.47	-0.05	0.57
	Max. corr.	0.41	0.44	0.48	0.16	0.71
	Lead/lag	1	1	1	5	2
FRA	Contem. corr.	0.34	0.51	0.09	0.2	0.62
	Max. corr.	0.37	0.52	0.19	0.33	0.85
	Lead/lag	1	1	5	2	2
ITA	Contem. corr.	0.27	0.23	0.51	-0.02	0.31
	Max. corr.	0.42	0.43	0.62	0.41	0.5
	Lead/lag	3	4	2	5	2
ESP	Contem. corr.	0.28	0.47	0.19	0.02	0.64
	Max. corr.	0.39	0.66	0.31	0.39	0.75
	Lead/lag	2	2	-3	5	2
NLD	Contem. corr.	0.34	0.2	0.66	0.29	0.8
	Max. corr.	0.38	0.26	0.69	0.33	0.82
	Lead/lag	1	2	1	1	1
BEL	Contem. corr.	0.33	-	0.43	0.24	0.69
	Max. corr.	0.38	-	0.52	0.25	0.72
	Lead/lag	1	-	1	2	1
AUT	Contem. corr.	0.15	0.24	0.03	0.06	0.59
	Max. corr.	0.2	0.35	0.09	0.08	0.62
	Lead/lag	1	1	-4	1	1
FIN	Contem. corr.	0.16	-0.51	0.31	0.63	0.72
	Max. corr.	0.37	0.53	0.36	0.74	0.8
	Lead/lag	3	5	2	1	1
USA	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
CAN	Contem. corr.	0.76	0.72	0.87	0.81	0.79
	Max. corr.	0.76	0.73	0.87	0.82	0.79
	Lead/lag	0	1	0	1	0
UK	Contem. corr.	0.59	0.63	0.5	0.6	0.55
	Max. corr.	0.59	0.63	0.56	0.67	0.61
	Lead/lag	0	0	-3	1	1
JPN	Contem. corr.	0.21	0.28	0.21	-0.13	0.19
	Max. corr.	0.23	0.28	0.41	0.05	0.21
	Lead/lag	2	0	4	5	1
SWE	Contem. corr.	0.46	-	0.66	0.25	0.53
	Max. corr.	0.51	-	0.66	0.49	0.67
	Lead/lag	2	-	2	5	2

For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead (lag) of US if the value is positive (negative).

Table 2A: Correlation of BK filtered GDP with respect to Germany

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 – 2002
DEU	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
FRA	Contem. corr.	0.59	0.70	0.26	0.88	0.70
	Max. corr.	0.59	0.70	0.65	0.88	0.75
	Lead/lag	0	0	-5	0	1
ITA	Contem. corr.	0.31	0.20	0.63	0.80	0.88
	Max. corr.	0.31	0.20	0.63	0.80	0.91
	Lead/lag	0	0	0	0	1
ESP	Contem. corr.	0.48	0.45	0.26	0.88	0.49
	Max. corr.	0.50	0.68	0.56	0.88	0.54
	Lead/lag	1	2	-5	0	1
NLD	Contem. corr.	0.69	0.64	0.88	0.76	0.24
	Max. corr.	0.69	0.64	0.88	0.76	0.39
	Lead/lag	0	0	0	0	2
BEL	Contem. corr.	0.71	-	0.57	0.87	0.90
	Max. corr.	0.77	-	0.70	0.87	0.90
	Lead/lag	-1	-	-2	-1	0
AUT	Contem. corr.	0.72	0.73	0.60	0.81	0.30
	Max. corr.	0.75	0.83	0.67	0.81	0.30
	Lead/lag	1	1	-1	0	0
FIN	Contem. corr.	0.14	0.99	0.31	0.10	0.57
	Max. corr.	0.35	0.99	0.62	0.68	0.57
	Lead/lag	-4	0	-3	-5	0
USA	Contem. corr.	0.44	0.53	0.52	-0.55	0.21
	Max. corr.	0.48	0.53	0.65	0.49	0.37
	Lead/lag	-1	-1	-2	-5	-2
CAN	Contem. corr.	0.35	0.57	0.47	-0.22	0.63
	Max. corr.	0.35	0.57	0.56	0.54	0.78
	Lead/lag	-1	0	-1	-5	-2
UK	Contem. corr.	0.40	0.64	0.11	-0.25	0.84
	Max. corr.	0.47	0.64	0.65	0.54	0.84
	Lead/lag	-2	0	-5	-5	-1
JPN	Contem. corr.	0.55	0.54	0.59	0.54	0.03
	Max. corr.	0.60	0.60	0.69	0.56	0.66
	Lead/lag	-1	-1	-2	-1	5
SWE	Contem. corr.	0.53	-	0.66	0.69	0.81
	Max. corr.	0.60	-	0.66	0.75	0.84
	Lead/lag	-1	-	-1	-1	1

For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead (lag) of Germany if the value is positive (negative).

Table 2B: Correlation of BK filtered GDP with respect to US

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 – 2002
DEU	Contem. corr.	0.44	0.53	0.52	-0.55	0.21
	Max. corr.	0.48	0.54	0.59	NA	0.34
	Lead/lag	1	1	1	NA	2
FRA	Contem. corr.	0.35	0.57	0.11	-0.44	0.27
	Max. corr.	0.41	0.64	0.20	0.03	0.74
	Lead/lag	1	1	3	5	3
ITA	Contem. corr.	0.34	0.34	0.51	-0.37	0.11
	Max. corr.	0.55	0.62	0.64	0.45	0.71
	Lead/lag	3	3	2	5	4
ESP	Contem. corr.	0.25	0.34	0.28	-0.52	0.53
	Max. corr.	0.36	0.57	0.39	0.16	0.67
	Lead/lag	3	2	-3	5	3
NLD	Contem. corr.	0.32	0.08	0.73	-0.41	0.50
	Max. corr.	0.40	0.21	0.78	0.16	0.53
	Lead/lag	2	2	1	5	1
BEL	Contem. corr.	0.33	-	0.76	-0.32	0.40
	Max. corr.	0.33	-	0.76	0.09	0.51
	Lead/lag	0	-	0	5	2
AUT	Contem. corr.	0.13	0.25	0.04	-0.58	0.12
	Max. corr.	0.22	0.41	0.11	0.03	0.58
	Lead/lag	2	2	-2	5	5
FIN	Contem. corr.	0.28	0.37	0.40	0.43	0.66
	Max. corr.	0.41	0.99	0.41	0.63	0.70
	Lead/lag	3	5	1	2	1
USA	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
CAN	Contem. corr.	0.77	0.78	0.90	0.68	0.61
	Max. corr.	0.79	0.82	0.90	0.79	0.77
	Lead/lag	1	1	0	2	1
UK	Contem. corr.	0.66	0.76	0.48	0.64	0.59
	Max. corr.	0.66	0.77	0.61	0.75	0.64
	Lead/lag	0	1	-5	2	1
JPN	Contem. corr.	0.29	0.41	0.31	-0.62	-0.33
	Max. corr.	0.32	0.42	0.47	NA	0.32
	Lead/lag	1	1	4	NA	-5
SWE	Contem. corr.	0.39	-	0.76	-0.19	0.25
	Max. corr.	0.50	-	0.76	0.65	0.80
	Lead/lag	5	-	0	5	4

For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead (lag) of Germany if the value is positive (negative). NA indicates that the maximum correlation is not available due to all correlations being negative in the window of five leads and lags.

Table 3A: **Correlation of annual differences of GDP with respect to Germany**

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 – 2002
DEU	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
FRA	Contem. corr.	0.66	0.61	0.46	0.62	0.80
	Max. corr.	0.66	0.61	0.46	0.62	0.80
	Lead/lag	0	0	-5	0	0
ITA	Contem. corr.	0.47	0.29	0.49	0.60	0.78
	Max. corr.	0.47	0.29	0.49	0.60	0.81
	Lead/lag	0	0	0	0	1
ESP	Contem. corr.	0.45	0.27	0.49	0.63	0.74
	Max. corr.	0.45	0.38	0.65	0.63	0.74
	Lead/lag	0	2	-5	0	0
NLD	Contem. corr.	0.58	0.41	0.79	0.60	0.67
	Max. corr.	0.58	0.41	0.79	0.62	0.67
	Lead/lag	0	0	0	-1	0
BEL	Contem. corr.	0.68	-	0.68	0.76	0.91
	Max. corr.	0.68	-	0.68	0.76	0.91
	Lead/lag	0	-	0	0	0
AUT	Contem corr.	0.65	0.57	0.64	0.64	0.69
	Max. corr.	0.65	0.64	0.64	0.64	0.69
	Lead/lag	0	2	0	0	0
FIN	Contem. corr.	0.05	0.10	-0.19	0.18	0.76
	Max. corr.	0.12	0.54	0.16	0.22	0.76
	Lead/lag	-5	2	-3	-2	0
USA	Contem. corr.	0.43	0.42	0.47	0.08	0.55
	Max. corr.	0.47	0.47	0.52	0.13	0.55
	Lead/lag	-1	-1	-1	-2	0
CAN	Contem. corr.	0.41	0.38	0.33	0.10	0.65
	Max. corr.	0.43	0.43	0.42	0.27	0.77
	Lead/lag	-1	1	-1	-2	-1
UK	Contem. corr.	0.40	0.52	0.34	0.01	0.60
	Max. corr.	0.41	0.52	0.47	0.16	0.69
	Lead/lag	-1	0	-5	-3	-1
JPN	Contem. corr.	0.59	0.49	0.55	0.35	0.24
	Max. corr.	0.61	0.50	0.68	0.45	0.35
	Lead/lag	-1	-1	-1	-1	-1
SWE	Contem. corr.	0.40	-	0.35	0.51	0.82
	Max. corr.	0.41	-	0.37	0.54	0.82
	Lead/lag	-1	-	-3	-1	0

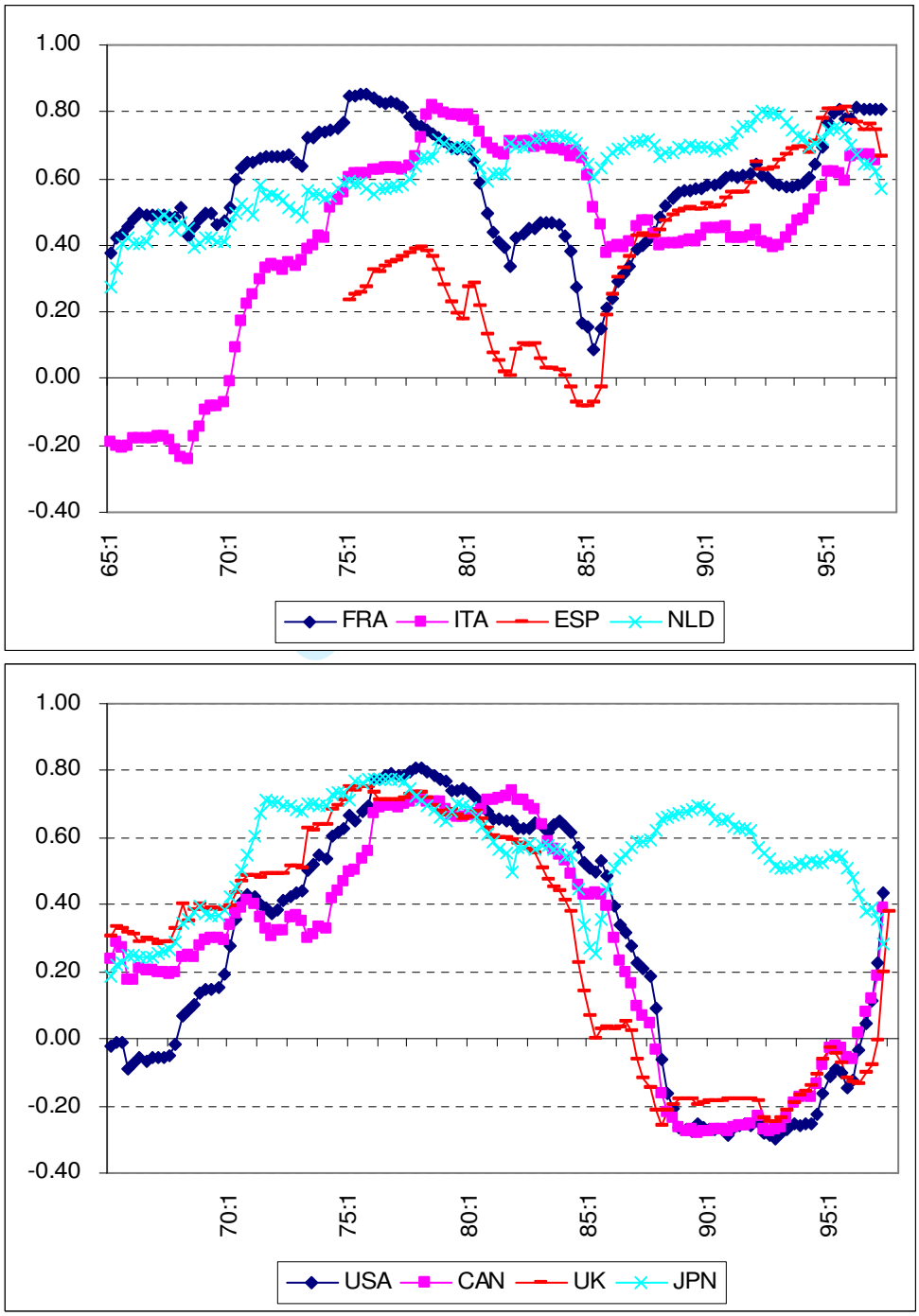
For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead (lag) of Germany if the value is positive (negative).

Table 3B: **Correlation of annual differences of GDP with respect to US**

		Whole Smpl	1960 - 1979	1980 - 1990	1991 - 2002	1993 – 2002
DEU	Contem. corr.	0.43	0.42	0.47	0.08	0.55
	Max. corr.	0.47	0.47	0.5	0.27	0.61
	Lead/lag	1	1	1	2	1
FRA	Contem. corr.	0.39	0.45	0.07	0.43	0.47
	Max. corr.	0.42	0.46	0.32	0.46	0.72
	Lead/lag	1	1	3	5	2
ITA	Contem. corr.	0.35	0.31	0.38	0.19	0.23
	Max. corr.	0.44	0.41	0.66	0.43	0.43
	Lead/lag	2	2	2	5	2
ESP	Contem. corr.	0.26	0.24	0.26	0.22	0.42
	Max. corr.	0.31	0.34	0.34	0.66	0.62
	Lead/lag	2	2	-3	5	3
NLD	Contem. corr.	0.39	0.19	0.59	0.49	0.75
	Max. corr.	0.45	0.31	0.65	0.52	0.77
	Lead/lag	1	2	1	1	1
BEL	Contem. corr.	0.37	-	0.37	0.40	0.6
	Max. corr.	0.41	-	0.53	0.40	0.67
	Lead/lag	1	-	2	0	1
AUT	Contem. corr.	0.13	0.09	0	0.10	0.52
	Max. corr.	0.2	0.25	0.09	0.21	0.52
	Lead/lag	1	2	5	5	0
FIN	Contem. corr.	0.24	-0.6	0.02	0.79	0.73
	Max. corr.	0.41	0.51	0.2	0.84	0.85
	Lead/lag	3	4	4	1	1
USA	Contem. corr.	1.00	1.00	1.00	1.00	1.00
	Max. corr.	1.00	1.00	1.00	1.00	1.00
	Lead/lag	0	0	0	0	0
CAN	Contem. corr.	0.76	0.7	0.86	0.85	0.76
	Max. corr.	0.76	0.7	0.86	0.85	0.77
	Lead/lag	0	0	0	0	1
UK	Contem. corr.	0.53	0.47	0.5	0.76	0.59
	Max. corr.	0.53	0.47	0.5	0.77	0.59
	Lead/lag	0	0	0	1	0
JPN	Contem. corr.	0.29	0.31	0.28	-0.11	0.28
	Max. corr.	0.29	0.31	0.46	NA	0.31
	Lead/lag	0	0	5	NA	-1
SWE	Contem. corr.	0.50	-	0.72	0.47	0.42
	Max. corr.	0.50	-	0.72	0.59	0.55
	Lead/lag	0	-	0	5	2

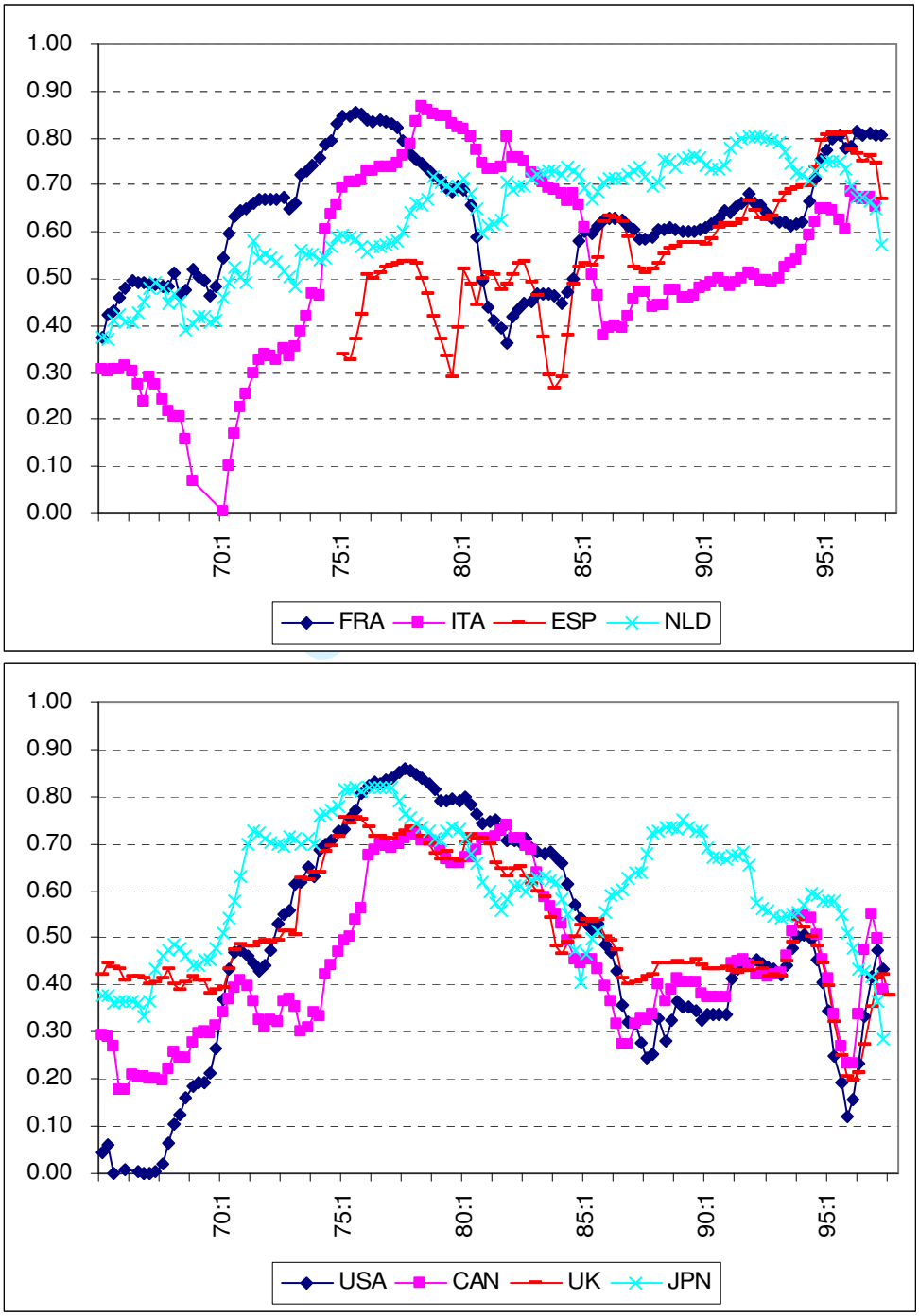
For each variable the first row contains the contemporary correlation; the second row the maximum (positive) correlation for a window of five leads and five lags. The number in the third row shows, for the maximum correlation, the lead(lag) of Germany if the value is positive(negative).

Figure 1: **Contemporary rolling correlation of HP detrended GDP with respect to Germany**



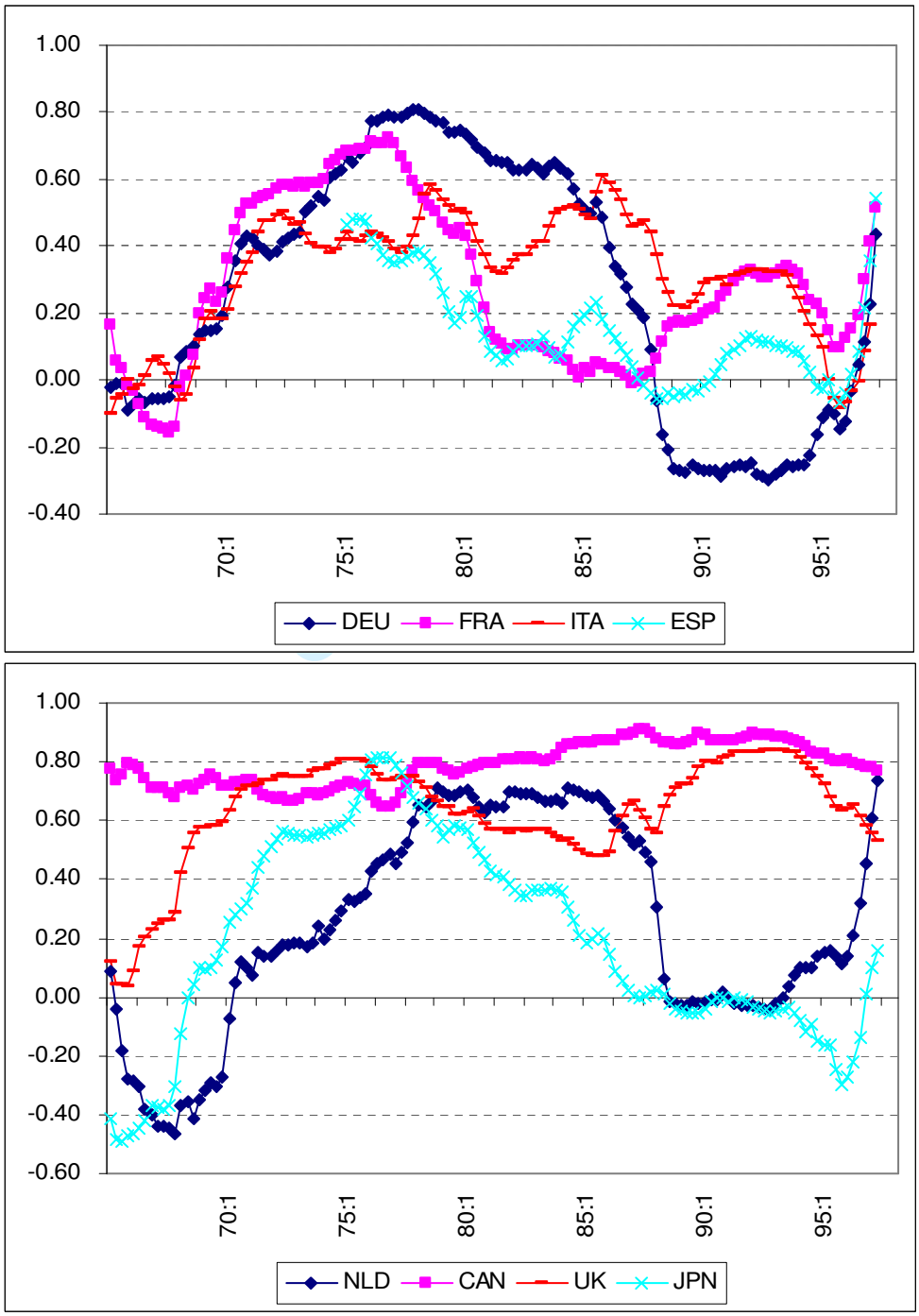
Note: Rolling correlations are calculated for a temporal window of 10 years.

Figure 2: **Maximum positive rolling correlation of HP detrended GDP with respect to Germany**



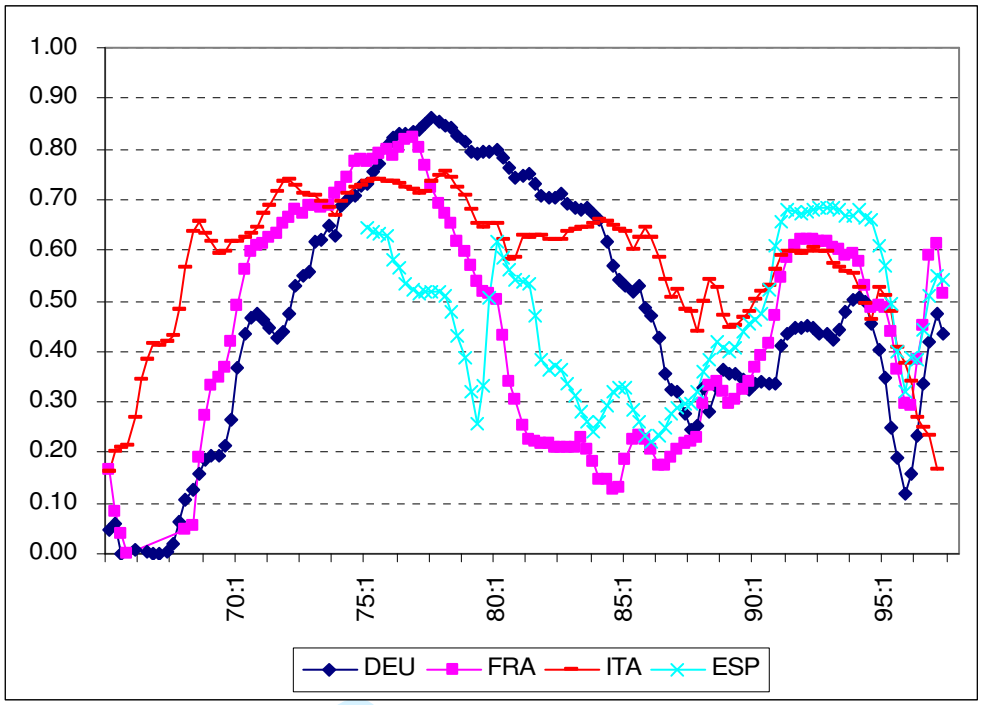
Note: Rolling correlations are calculated for a temporal window of 10 years. Maximum correlation is computed over a range of five leads and five lags.

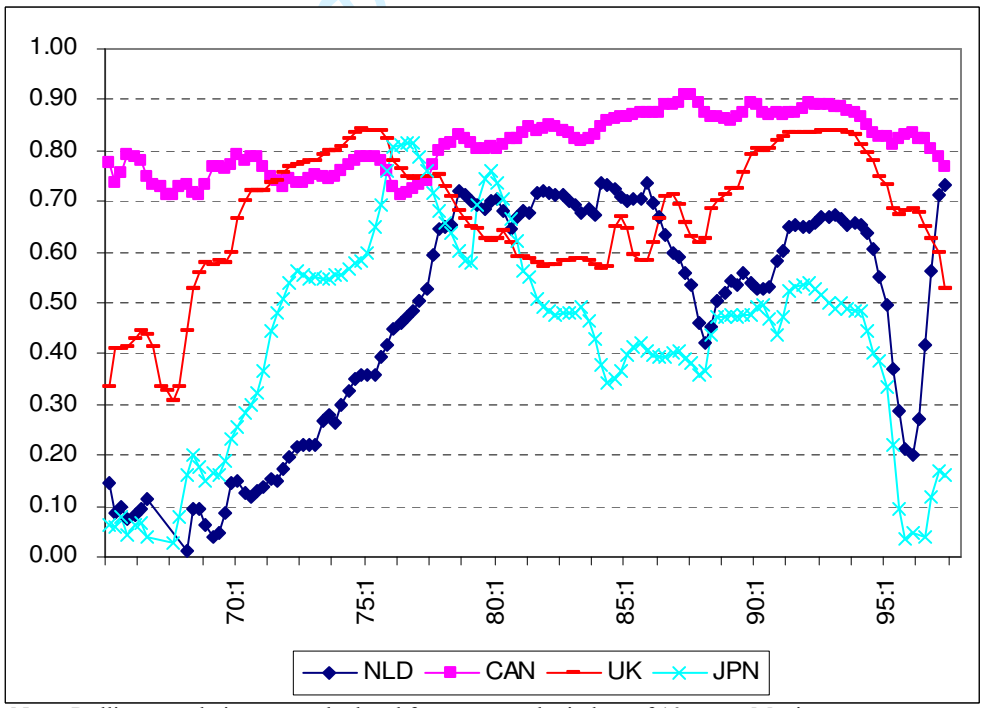
Figure 3: **Contemporary rolling correlation of HP detrended GDP with respect to the US**



Note: Rolling correlations are calculated for a temporal window of 10 years.

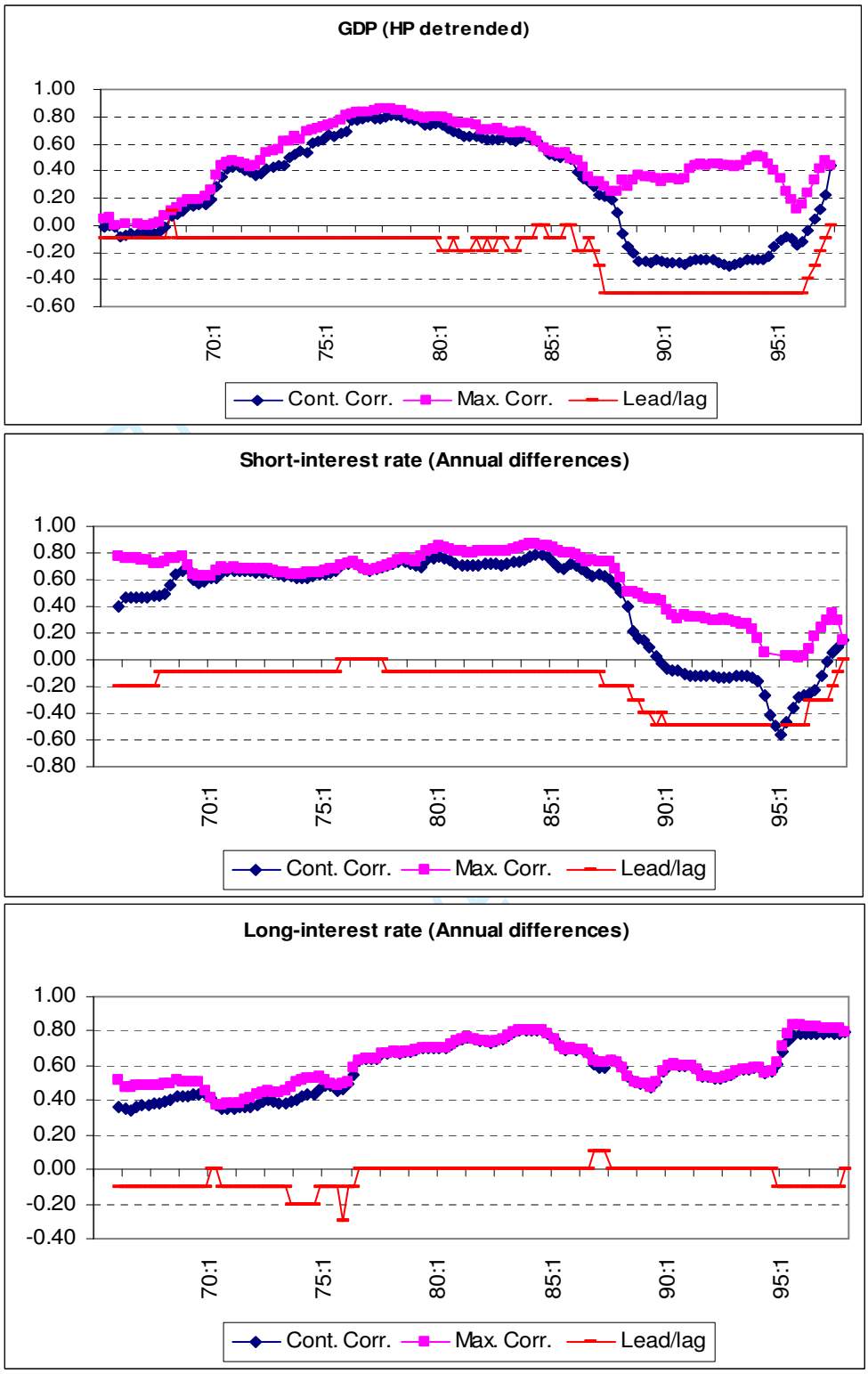
Figure 4: **Maximum positive rolling correlation of HP detrended GDP with respect to the US**





Note: Rolling correlations are calculated for a temporal window of 10 years. Maximum correlation is computed over a range of five leads and five lags.

Figure 5: **Rolling contemporary and maximum correlations and lead/lag for the US with respect to Germany**



Notes: Rolling correlations are calculated for a temporal window of 10 years. Maximum correlation is computed over a range of five leads and five lags. The leads/lags are divided by 10, for presentation purposes, to make the values of this variable comparable to the values of the correlations.